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PRELIMINARY REPORT OF THE EXPERIMENTAL SEPTIC TANK AT THE UNIVERSITY OF KANSAS.*

BY JOHN S. WORLEY.

With plates XXIX to XL.

IN connection with the study of problems in sanitary engineering related to the rapid, efficient and economical disposal of sewage, a septic-tank system was installed south of the Fowler Shops, at the University of Kansas, and some analyses have been made of the effluent at various points in the system. The tank was built in the winter of 1903–'04, with the cooperation and under the supervision of Prof. W. C. Hoad, of the engineering department. The analyses of the effluent were made in the water-analysis laboratory. It is to be regretted that the series of analyses does not cover a longer period, but the end of the college year made it necessary to suspend operations. It is expected that the work will be continued by other students in the department.

The objects of the experiments were to study the workings of a septic tank, to note the effect of aeration on the effluent from the tank, and to see if, after thorough aeration, a second bacterial action could be secured in a second tank. A record was made of the approximate composition of the sewage treated, and the samples of effluent were taken at such points in the system as would show the efficiency at the stages mentioned.

The main tank was situated at the mouth of the sewer leading from the Fowler Shops. It was built of brick laid in Iola Portland cement and plastered with the same. Its inside measurements were 2 feet 6 inches wide, 3 feet deep, and 10 feet

*Abstract from a thesis presented to the faculty of the Graduate School of the University of Kansas for the degree of Master of Science; written under direction of Prof. Edward Bartow.

long, and it had a capacity of 68 cubic feet. The sewage entered the upper end through a tile which dipped under the surface; the effluent passed out over a two-foot weir at the opposite end. Just in front of the weir was a baffle board which extended to a depth of a foot below the surface, that the effluent be not drawn from the surface. After passing over the weir the water fell into a division box provided with an overflow and a small gate for regulating the amount to be aerated.

That part of the effluent used for aeration was led through 40 feet of 4-inch troughing to aeration boxes. These troughs contained seven cross-weirs, over which the water passed in thin sheets, thus coming in contact with air. After leaving the trough the water passed through a series of boxes, one placed above the other. These boxes were 1 foot 6 inches long, 8 inches wide, and 3 inches deep; each was provided with a weir 1 foot long, so that the water on leaving the box passed over this weir in a thin sheet, then dropped to the next box in single drops.

After leaving the aeration boxes the water was led by a short trough into the second tank, of the dimensions 1 foot 9 inches wide, 1 foot 6 inches deep, and 4 feet long, of the same construction as the large tank, and with a capacity of 10½ cubic feet. Both tanks had board covers, to keep out the direct sunlight.

The plan of the system is shown in plate XXIX and the elevation in plate XXX.

The sewage used was that from the two closets, the two urinals and the wash-room of Fowler Shops. The time of passage from the shops to the first tank was less than two minutes; so the solid material had no chance to go into solution or disintegrate. Owing to the solid matter having to pass directly into the tank, no analysis could be made of the sewage before its entrance. An automatic register was attached to the closets (see table I), and an account was kept of the amount of soap and sawdust used in the wash-room (see table II and plate XXXI). Owing to lack of time, no record was obtained of the number of times the urinals were used each day.

Samples of the effluent were collected in three places—as the water left the first septic tank, as it left the last aeration box, and as it left the small tank—the samples from these places

TABLE No. I.—Number of times closets were used each day.

DATE.		Times used.	DATE.		Times used.
April	12	10	May	2	22
"	13	23	"	3	15
"	14	20	"	4	19
"	15	7	"	5	31
"	16	20	"	6	31
"	17	26	"	7	24
"	18	30	"	9	15
"	19	33	"	10	25
"	20	22	"	11	25
"	21	22	"	12	25
"	22	24	"	13	23
"	23	24	"	14	25
"	24	21	"	16	30
"	26	22	"	17	45
"	27	25	"	18	35
"	28	32	"	19	35
"	29	31			
"	30	35			

TABLE No. II.—Amount of lye, soap, and sawdust.

DATE.		Amount used, in grams.					
		H. H. soap.		Lye soap.		Sawdust.	
From—	To—	Per day.	Per week.	Per day.	Per week.	Per day.	Per week.
March 14..	Mar. 21..	195	1.370	770	5,400	110	760
" 21..	" 23..	250	1.500	857	5,950	250	1,300
" 28..	April 4..	250	1,500	1,085	6,510	248	1,485
April 4..	" 11..	173	1.040	833	5,005	193	1,160
" 11..	" 18..	180	1,080	871	5.270	170	1,000
" 18..	" 25..	241	1,448	795	4,770	215	1,300
" 25..	May 2..	262	1,572	510	3,060	178	1,070
May 2..	" 9..	228	1,785	360	2,150	228	1,360
" 9..	" 16..	176	954	256	1,540	230	1.400
" 16..	" 23..	250	1,500	883	5,300	200	1.200

being designated as I, II, and III, respectively. Collections were made on Mondays, at twelve noon and five P. M.; on Wednesdays and Fridays, at eight A. M., twelve noon, and five P. M. Each sample contained one liter, which was taken directly to the laboratory and divided into two parts. That part to be used in determining the ammonias and the oxygen consumed was sterilized with 4 c. c. of a solution of one part sulfuric acid and three parts water; that part from which the other determinations were to be made was sterilized with 4 c. c. of a solution of one part formaline and three parts water. This method of sterilization was found to be perfectly satisfactory. The corresponding parts of each sample taken during the day

were placed in the bottle, and samples drawn from this bottle were called the average for that day. Analyses for the week were made on the following Saturday.

In the chemical analysis the usual methods were adopted, with one variation, that being in the determination of nitrogen as nitrates.

Total Solids.—Fifty c. c. of the sample were evaporated on the water-bath to dryness; allowed to remain for twenty minutes, in order to have it as dry as possible, at the temperature of the water-bath; the bottom of the dish wiped with a clean cloth; and the dish was allowed to cool in a desiccator for one-half of an hour, then weighed. Afterward the dish was heated to a low redness and weighed, to determine the loss on ignition.

Hardness.—This determination was made by diluting 25 c. c. with 100 c. c. of pure distilled water and using the common Clark method.

Chlorine.—Fifty c. c. were titrated with a standard silver-nitrate solution, using potassium chromate as indicator.

Oxygen Consumed.—One hundred c. c. were treated by the Kubel method.

Free Ammonia.—Five c. c. of the water were added to 500 c. c. of ammonia-free water, and placed in a distilling flask, from which 150 c. c. were distilled and nesslerized in the usual manner.

Albuminoid Ammonia.—To the water remaining in the flask after the free ammonia had been determined were added 50 c. c. of alkaline permanganate solution, and the distillation and nesslerization carried on in the usual way.

Nitrogen as Nitrites.—Five c. c. of the water were diluted to 50 c. c., acidified with one drop of hydrochloric acid, and 1 c. c. each of sulfanilic acid and napthlamine hydrochloride added.

Nitrogen as Nitrates.—Fifty c. c. were evaporated to dryness in order to drive off the ammonia, diluted up to its original volume, and placed in a Nessler jar; to this were added four inches of aluminum wire and 2 c. c. of pure concentrated sodium hydroxide; then allowed to stand for twenty-four hours. One c. c. of this solution was then diluted to 50 c. c. with ammonia-free water, and nesslerized in the usual manner, to determine

the ammonia, these determinations being reduced to nitrogen by multiplying by 0.82.

The sewage was turned into the plant on March 5, and analyses started April 18, extending to May 23. The following table shows the results of the analyses, and plates XXXII to XL show a comparison of the various results at the three points of collection:

TABLE III.—Chemical analyses. (Parts per million.)

Number	Date of collection.	Total solids	Loss on ignition	Hardness	Chlorine	Oxygen consumed	Ammonia.		Nitrogen as—	
							Free	Albuminoid	Nitrates	Nitrites
I, 1	.....	910	270	160.0	124.0	17.9	.....	.....	.....	.....
II, 2	.....	794	200	180.0	116.0	14.3	.....	.....	.....	.....
III, 3	.....	740	160	180.0	110.0	10.0	.....	.....	.....	.....
I, 4	.....	1104	428	150.0	152.0	31.1	.....	.....	.....	.....
II, 5	.....	936	330	150.0	152.0	27.0	.....	.....	.....	.....
III, 6	.....	920	330	250.0	138.0	20.2	.....	.....	.....	.....
I, 7	.....	890	310	140.0	108.0	21.5	.....	.....	.....	.....
II, 8	.....	930	250	190.0	122.0	18.5	.....	.....	.....	.....
III, 9	.....	820	240	200.0	112.0	18.4	.....	.....	.....	.....
I, 10	May 2.....	4200	.....	170.0	112.0	36.2	31.10	20.70	0.28	19.63
II, 11	" 2.....	3860	.....	150.0	91.2	32.3	43.00	23.50	0.24	30.34
III, 12	" 2.....	4170	.....	150.0	134.0	26.0	30.20	25.00	0.35	24.60
I, 13	May 4.....	4000	3100	90.0	134.0	32.2	84.50	17.30	0.32	49.20
II, 14	" 4.....	3660	2780	120.0	132.8	28.6	63.00	13.50	0.24	44.28
III, 15	" 4.....	3680	2780	200.0	132.8	28.0	1.80	42.20	0.10	65.60
I, 16	May 6.....	3940	3100	250.0	67.2	23.0	11.90	10.20	0.07	9.60
II, 17	" 6.....	3940	3080	250.0	60.0	9.9	16.70	8.60	0.28	13.94
III, 18	" 6.....	4590	3740	240.0	58.4	9.5	21.40	17.00	0.32	15.16
I, 19	May 9.....	1460	640	530.0	104.0	15.9	19.70	14.50	0.16	18.50
II, 20	" 9.....	800	400	549.6	100.0	16.0	23.50	12.70	0.24	19.68
III, 21	" 9.....	940	460	509.6	90.0	14.3	20.00	12.30	0.22	19.68
I, 22	May 11.....	860	360	479.6	98.0	14.1	20.80	8.80	0.12	22.55
II, 23	" 11.....	896	336	479.6	115.0	10.9	22.00	8.20	0.22	22.55
III, 24	" 11.....	880	296	479.6	92.0	9.2	23.00	8.20	0.20	22.55
I, 25	May 13.....	2080	1220	479.6	108.0	17.0	26.40	9.00	0.12	28.70
II, 26	" 13.....	2126	1280	479.6	104.0	14.5	32.50	9.20	0.22	31.16
III, 27	" 13.....	2080	1200	479.6	96.0	11.4	26.00	6.20	0.24	31.16
I, 28	May 16.....	960	368	440.0	84.0	13.5	9.80	19.10	0.11	6.56
II, 29	" 16.....	960	340	440.0	92.0	10.5	23.50	8.20	0.24	13.12
III, 30	" 16.....	900	340	448.0	76.0	9.2	15.20	6.90	0.24	7.38
I, 31	May 18.....	3430	1320	440.0	110.0	12.3	17.00	9.30	0.04	8.20
II, 32	" 18.....	920	280	440.0	108.0	10.3	11.00	21.50	0.22	13.12
III, 33	" 18.....	860	320	400.0	88.0	7.4	0.20	22.50	0.22	7.38
I, 34	May 20.....	1944	1040	400.0	102.0	15.5	19.20	11.20	0.19	11.38
II, 35	" 20.....	2020	1190	360.0	102.0	12.5	19.40	7.40	0.17	11.38
III, 36	" 20.....	2132	1312	360.0	118.0	9.8	21.80	6.50	0.12	13.12
I, 37	May 23.....	840	380	320.0	106.0	16.9	0.40	28.20	0.18	13.12
II, 38	" 23.....	850	370	320.0	114.0	15.5	32.90	10.80	0.90	24.60
III, 39	" 23.....	750	340	260.0	100.0	13.0	22.00	9.80	0.90	14.35
I, 40	May 25.....	4380	3500	320.0	114.0	19.1	10.90	10.60	0.05	16.40
II, 41	" 25.....	3872	3072	400.0	114.0	15.1	0.20	33.40	0.04	14.35
III, 42	" 25.....	4250	3506	360.0	100.0	14.3	0.20	35.60	0.04	12.30

In this short time no definite conclusions can be drawn. However, the data obtained are suggestive of fields for investigation, and attention is called to the following things, as shown by table III:

The plant has not yet reached its maximum efficiency.

Aeration in itself is of value in bringing about purification.

Some purification is taking place in the second tank, but it requires more time before any conclusion can be drawn as to the changes which are brought about.

In the analysis the amount of dilution is such as to give opportunity for error in the methods described by Phelps (Journal of Infectious Diseases I, 327–340) for ammonia determinations.

From May 9 to 16, the average amount of soap, lye, sawdust, and toilet-paper—non-nitrogenous matter—was 625 grams; the amount of human excrement—nitrogenous matter—was 800 grams; from the 16th to the 23d, the amount of soap, etc., was 1500 grams, the human excrement remaining the same; however there is nothing in the analysis indicative of what became of the excessive amount of non-nitrogenous organic matter entering the tank.

After the plant had been in operation for some time the hardness of the effluents increased to about twice that of the city water used in the toilet-room. This is just opposite to what was expected, and at present cannot be accounted for. The hardness of the city water was determined by the same soap solution as was used in that determination of the sewage effluents.

The average amount of non-nitrogenous matter entering the plant is higher than the nitrogenous organic matter.